a private. He was an honorary LL.D. of his own university of Glasgow (1938) and an honorary bencher of the Middle Temple (1940). As a member of an old Rutherglen family (his father, grandfather, and great-grandfather all having been provosts of the burgh) he received the freedom of that ancient and royal burgh on the celebration of its octocentenary in 1926. He died in Edinburgh without issue after a very brief illness 20 October 1944, survived by his wife, whom he married in 1913, Beatrice Joan, daughter of James Swan, a well-known Scottish livestock dealer. Genial and kindly in manner, in personal appearance Fleming was of middle height and good physique, and greatly attached to open-air life. Fishing, shooting, golf, and (in his earlier years) mountaineering all claimed his active pursuit in his leisure.

[Personal knowledge.] JOHN CAMERON.

FLEMING, SIR (JOHN) AMBROSE (1849–1945), electrical engineer and inventor of the wireless valve, was born at Lancaster 29 November 1849, the eldest child of the Rev. James Fleming, D.D., a Congregational minister, by his wife, Mary Ann, daughter of John Bazley White, of Swanscombe, Kent, a pioneer in the manufacture of Portland cement. His mother's eldest sister, Ellen Henrietta Ranyard [q.v.], founded the female Bible mission known later as the Ranyard Mission. In 1853 James Fleming and his family moved to London where he continued his ministry at Kentish Town, living in or near Tufnell Park until his death in 1879.

Ambrose Fleming was educated at University College School and University College, London. He obtained his B.Sc. in 1870, being placed, with only one other candidate, in the first division, despite the fact that for the last two years he had been working as a clerk with a firm of stockbrokers and was able to study only in his spare time. Subsequently (1872–4) he studied at South Kensington, first under (Sir) Edward Frankland and later under Frederick Guthrie [qq.v.]. This time was sandwiched between two periods as a science master, the one at Rossall School and the other at Cheltenham College. In 1877 he entered St. John's College, Cambridge, having won an entrance exhibition and saved £400 to pay the fees. Later, he was awarded a foundation scholarship and won several prizes. His object in going up was to attend the lectures of J. Clerk Maxwell [q.v.] and to work in the Cavendish Laboratory. He had previously studied Clerk Maxwell's famous *Treatise on Electricity and Magnetism* (2 vols., 1873), and was an ardent admirer of Clerk Maxwell, even though the lecturer's 'paradoxical and allusive way of speaking' made him difficult to follow. In the laboratory, Fleming's main research was on the development and use of a special resistance bridge for the accurate comparison of standards of resistance, and the bridge which he devised, nicknamed 'Fleming's banjo', was subsequently used for several years in the Cavendish Laboratory. In 1880, having in the previous year obtained the degree of D.Sc. (London), he was placed in the first class, in chemistry, physics, and mineralogy, in the natural sciences tripos with distinction in physics.

After serving as demonstrator in mechanism and applied mechanics at Cambridge, Fleming was appointed in 1881 to the newly created chair of mathematics and physics at University College, Nottingham, but resigned this post in the following year to take up consulting work in London with the Edison Electric Light Company. In 1883 he was elected into a fellowship at St. John's. In the next year he gave a few lectures on electrical technology at University College, London, and in 1885 was appointed professor. His forty-one years of service to electrical engineering in this chair coincided with a rapid growth in the subject, and he was one of the small number of English scientists who contributed greatly to its progress. Fleming used to say (but this was exaggeration) that on his appointment he found the equipment to consist of a blackboard and a piece of chalk. An electrical laboratory was founded and new laboratories were opened in 1893 by the Duke of Connaught. During the early years of his professorship, Fleming, besides his teaching, was engaged on practical problems dealing with alternating-current transformers and high-voltage transmission. He read important papers on these subjects to the Institution of Electrical Engineers and in 1889 and 1892 he published his two volumes on *The Alternate Current Transformer* which for many years was a standard treatise. In pure science he collaborated with (Sir) James Dewar [q.v.] at the Royal Institution, and during the six years 1892–8 there were published from the results of their work seventeen joint papers on the electrical and magnetic properties of materials at the temperature of liquid air.

In the early days of electric lighting, Fleming was impressed by the need for an authoritative body to which questions of electrical standards might be referred. He read a paper on the subject in 1885 before the Society of Telegraph-Engineers and Electricians (later the Institution of Electrical Engineers). The negotiations which followed led to the establishment of the Board of Trade laboratory and Fleming's paper also marked a step forward towards the foundation of the National Physical Laboratory.

Fleming's attention had been drawn to photometry while he was working for the Edison Electric Light Company, and he became one of the leading expositors of the subject in this country. On the opening of the new electrical laboratory at University College the photometric gallery was one of its notable features. The paper which he read at the meeting of the British Association at Cambridge in 1904, 'On Large Bulb Incandescent Electric Lamps as Secondary Standards of Light', marks an important stage in the advance of photometry. Fleming was also known as 'the great apostle of the potentiometer', both for the contribution which he made to its development by introducing a continuously adjustable resistance and thereby making it direct-reading, and for his vision of the great possibilities inherent in the instrument, for it was he who induced R. E. B. Crompton [q.v.] to put it on the market in a practical form.

Fleming's name, however, will best be remembered in the field of wireless telegraphy. At University College he carried out almost unending experiments on wireless transmitters and receivers, and he gave special courses of experimental lectures on Hertzian or wireless waves at University College, the Royal Institution, and the Royal Society of Arts. He had unwittingly prepared himself in a remarkably thorough way for his most famous invention by his early work with Guthrie and his careful study of the Edison effect in carbon filament lamps in 1890 and 1896. This study led to his close connexion with Marconi and Marconi's Wireless Telegraphy Company, and so later to his work on the generating plant for the Atlantic transmission from Cornwall to Newfoundland, culminating in Marconi's successful reception of Morse signals across the Atlantic in December 1901.

In 1904 another great step forward was made with Fleming's experimental proof that the known rectifying property of a thermionic valve operating at power frequencies (say, 50 cycles/sec.) was still operative at wireless frequencies (say, 1,000,000 cycles/sec.). This is a root principle in the operation of the wireless valve in the radio set of the present time. His paper read before the Royal Society, 'On the Conversion of Electric Oscillations into Continuous Currents by means of a Vacuum Valve' (1905), gives the earliest scientific account of the 'Fleming' valve. In the same year he described his electric wave measurer, or cymometer as he called it, and demonstrated it to the Royal Society.

During his distinguished career, Fleming contributed more than a hundred important papers to the *Proceedings* of learned societies; more than one-third of them appeared in those of the Physical Society. His association with this society was indeed remarkable. He read the very first paper read to it on its foundation in 1874, and no less than sixty-five years later he read his last paper before it in 1939 and illustrated it with experiments. He was an active president of the Television Society of London from 1930 to the time of his death, and strongly supported J. L. Baird [q.v.] in his pioneering work. He was one of the leading teachers of his time. His flair for linking together the mathematical bases of little-understood phenomena with their practical effects was a factor which drew many distinguished engineers to his special lectures at University College, as well as to his Cantor lectures at the Royal Society of Arts. He also ranked highly as a popular scientific lecturer. Few men of his time could hold an audience so thoroughly as he did, for example, in his four courses of Christmas lectures at the Royal Institution in 1894, 1901, 1917, and 1921. His success was due alike to his care in selecting suitable experimental illustrations and to his unremitting attention to their effective demonstration. His crisp articulation was also a great advantage.

Besides those already mentioned, Fleming's valuable written works include *The Principles of Electric Wave Telegraphy* (1906) and *The Propagation of Electric Currents in Telephone and Telegraph Conductors* (1911). A collection of his scientific and allied papers, 149 in number, in five volumes, was presented to University College, London, in 1948 by Lady Fleming. His services were recognized by a knighthood in 1929, and he was the recipient of many honours. From the Royal Society, of which he was elected a fellow in 1892, he received the Hughes medal in 1910; he also received the Albert medal of the Royal Society of Arts (1921), the Faraday medal of the Institution of Electrical Engineers (1928), the Duddell medal of the Physical Society (1931), the gold medal of the Institute of Radio Engineers, U.S.A. (1933), the Franklin medal of the Franklin Institute, U.S.A. (1935), and the Kelvin medal of the engineering institutions of Great Britain (1935). He was elected an honorary fellow of his college at Cambridge in 1927 and in 1928 received the honorary degree of D.Eng. from Liverpool University. On his retirement in 1926 he became professor emeritus. He went to live at Sidmouth where he died, aged ninety-five, 18 April 1945.

In person, Fleming was remarkable for his mental alertness, forthrightness, power of concentration (increased perhaps by his deafness), and his ability to express himself clearly; but this very keenness at times made it difficult for him to suffer fools gladly. His main recreations were photography and sketching in watercolour. The photographs which he took by the wet-plate process of his younger days during his travels in Switzerland, and later in Italy and Egypt, have considerable artistic merit. A Congregationalist by upbringing, he inclined as years went on more to the Church of England on its evangelical side. That he held strong opinions on the relation of evolution to religion was shown by his presidency of the Victoria Institute from 1927 to 1942. His deep conviction of the truth of the Christian faith was manifested in later years by both his writings and his public utterances.

Fleming was twice married: first, in 1887 to Clara Ripley (died 1917), daughter of Walter Freak Pratt, solicitor, of Bath; secondly, in 1933 to Olive May, daughter of George Franks, business proprietor, of Cardiff. There were no children.

A portrait of Fleming by Sir William Orpen is at University College, London; the Institution of Electrical Engineers possesses a replica given to it by Fleming. A bust by G. H. Paulin (1932) is in the electrical engineering department of University College, London.

[Sir J. A. Fleming, *Memories of a Scientific Life*, 1934; W. H. Eccles in *Obituary Notices of Fellows of the Royal Society*, No. 14, November 1945; *Proceedings* of the Physical Society, November 1945; J. T. MacGregor-Morris, *The Inventor of the Valve*, 1954, and *Sir Ambrose Fleming* (*Jubilee of the Valve*) in *Notes and Records of the Royal Society*, March 1955; private information; personal knowledge.] J. T. MacGregor-Morris.

FLETT, Sir JOHN SMITH (1869–1947), geologist, was born at Kirkwall, Orkney, 26 June 1869, the second son of James Ferguson Flett, merchant and bailie, and his wife, Mary Ann Copland. He was educated at Kirkwall Burgh School and George Watson's College, Edinburgh, and in 1886 passed to the university of Edinburgh where, after a brilliant academic career, he graduated in arts and science (1892) and medicine (1894). After a short spell in medical practice, he joined the staff of the geological department of his university, then under the direction of his beloved teacher James Geikie. Soon after he became lecturer in petrology and during the next half-dozen years he laid, by study and research, the foundations of his distinguished career in that branch of his science. Among his earliest researches, noteworthy are his investigations into the stratigraphy of the Old Red Sandstone of Orkney and into the petrography of the remarkable suite of alkaline dykes found in this formation; on this Orkney work he was in 1900 awarded the D.Sc. of his university.

In 1901 Flett succeeded (Sir) Jethro Teall [q.v.] as petrographer to the Geological Survey of Great Britain. During his ten years' tenure of this post, he made petrological contributions to some thirty Survey memoirs ranging over the whole country, and thus acquired a comprehensive knowledge of British rocks which was to be of inestimable value in his later work. He was part-author of two important memoirs dealing with Land's End and the Lizard, and in these he studied in particular the relationships between intrusion and stress-action in igneous complexes. During this period he described the rocks of the Lewisian Inliers of the Northern Highlands and shared in the demonstration of polymetamorphism around the Inchbae Granite in Ross-shire. In another field, he proposed, with Henry Dewey, that the pillow-lavas and spilites formed an independent igneous suite indicative of a special geological environment.

Whilst Survey petrographer, Flett collaborated with Tempest Anderson,